New Design of the Wind Turbine for Maximum Amount of Energy Transfer in Minimum Flowing Wind

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Abstract: ***The present designs of the wind turbines are either not so efficient or affordable, when the implementation in the city area for household cases is considered. This new design of the wind turbine can be used even in the areas of scarce wind flow. This design is the union of several present efficient designs, and overcomes almost all the shortcomings of the present designs in the present condition of application. Such design has never been implemented and holds the great potential for the implementation.***

Keywords: Wind Turbine, Energy Efficient, Household, Multipurpose

1. Introduction

As the world is slowly running out of conventional fuel, we are moving toward unconventional energy sources like solar energy, tidal energy and wind energy. But one of the problems about utilizing wind energy is that the wind turbine stations are set on vast hilly areas where the wind flows abundantly. Such wind turbines are not so efficient when installed in cities [1], or on house roof-tops. It is because the turbine designs are made taking into consideration of open and windy areas. City areas are very much different than these. So such conventional turbine designs don't work-out in city spaces. This design discussed in the paper is very much effective in such scenarios and can be made with household things.

2. Design of the Turbine

2.1 Need of Design

As discussed above, the conventional wind turbines are less efficient in city environment. Also they utilize very small area for energy generation as compared to the total area taken by them for installation. Also the long height is required by these wind turbines for its installation.

The new design on the other hand, is suitable for city places with sparse wind conditions. It utilizes the wind in all the area in which it spans and also it can be installed anywhere. Also, it's height might even be from several centimeters to few meters. The actual design of the turbine is as shown in the Figure 1

2.2 Design of the Blades

The shape of the blades plays a crucial role in the design of the wind turbine. The best shape of the blade was derived by practical experimentation and trials, as the required parameters were too much and it was almost impossible for its calculation and simulation on software. From the experimentation, it was derived that the ratio of the blade span to the depth of the curve must be close to 5:2. Any deviation from the said ratio resulted into drop in efficiency and the turbine tended to lock down. The lock down here means that the blade acting like locked and was not rotating at lower wind speed. If the shape of the blade was closer to the shape specified, the turbine tended to work at full efficiency.

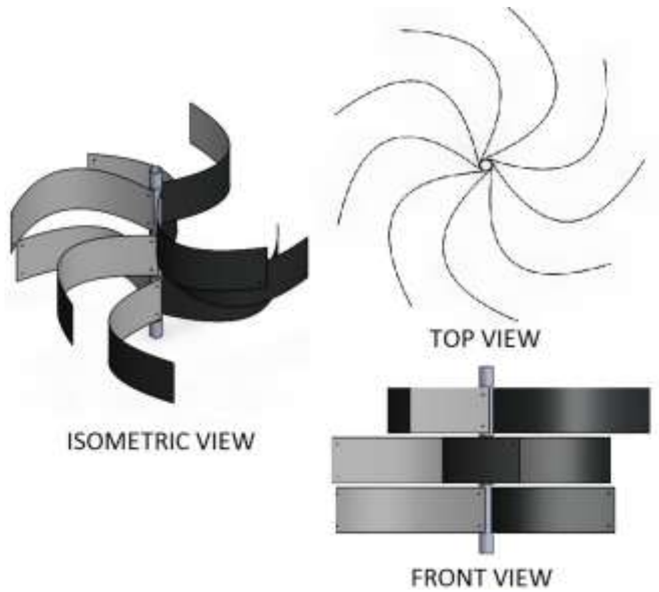

Figure 1: The Design of the Turbine

The surface of the blade which receives wind was made as smooth as possible. This helped in a better flow of the wind. But on the contrary the back side of the blade was coated with the bubble-wrap. According to Sauer Energy, a company of the vertical turbines, the dotted structure on the backside helps to disrupt the wind streams and due to this, the opposite force applied on the backside of the blade is reduced and this helps in better rotation even in negligible wind flowing. [2]

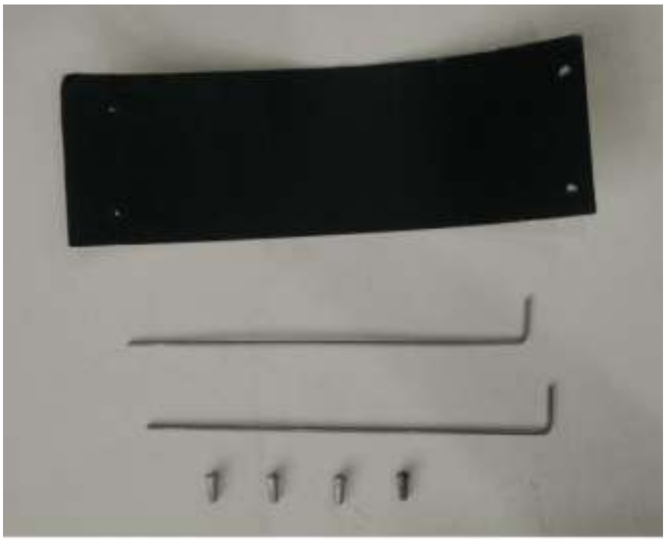

Figure 2: Parts of the Turbine

2.3 Design of the Levels

To maximize the wind usage the number of blades was needed to optimize. When the turbine was made with 2 blades, the condition would arise when the turbine would rotate in jerks, whereas when there were four, each blade would not get enough wind and the turbine would not rotate. None of these problems occurred during the three blade prototype. So it was deduced that the three blade turbine was best suitable. During the development of the turbine designs, few other designs were referred [3][4] and by merging these designs, the final design was made

2.4 Overall Design

The problem which occurred during a whole three blade turbine was that the condition would often arise where none of the blade would receive wind, as one of the blades would obstruct the flow. The design of tornado shaped turbine [5] would never have such problem, but such design was really hard to manufacture. So the two designs were combined and the resultant design was made with the three blade turbine split into three levels and each level was relatively rotated from one another such that the locking condition would never occur. This Design was proven to be most efficient and no such design existed before the design was made.

3. Process of Manufacturing

As stated earlier the prototype made was scaled down. The main criterion of manufacturing was kept so that it could be made in-house. So almost all the materials used was cheap and easily available. The materials used were PVC pipe, cycle spokes, and soft and thin cardboard paper.

A pipe of PVC was used as the central rod. It was drilled with the holes required for the mounting of the blades, so that in each level the blades would be separated by almost 120^{0} and each level would be in a phase difference of almost

Figure 3: Turbine implemented on a Robot

40^{0} with respect to previous level. For accurate measure of the angle with which the rotating pipe should be turned, the indexing head was used for the pipe and holes were taken with the help of sensitive drilling machine. When the drilling part was done the spokes were cut and bended at required length so that they should not get off the pipe by sliding. Corresponding holes were taken on the respective cardboard blades. As the card is going to get bent, the blade becomes rigid even with two supporting holes. After sliding in the cardboard through the spokes, a spoke-nut was tightened to prevent the cardboard to slide off the spike. The individual parts of the turbine can be seen in the Figure 2.

The length of the spoke required was kept so that it would be equal to the summation of the span of the blade required and the diameter of the pipe. The curvature of the blade was so adjusted that the ratio of the span to its curve depth was 5:2. But the cardboard material was vulnerable to the outer atmospheric conditions. So for the outdoor trials, laminated paper was used as the material of the blade.

4. Advantages Over Traditional Turbine

The resultant design was efficient and working even under low windy condition, unlike the traditional wind turbines. Also the vertical nature of the turbine made it independent of the direction of mounting. It didn't need to orient itself unlike other horizontal turbines. Also, as the generator would be placed at the bottom, the weight at the top was reduced

5. Cases of Application

The intended use of this turbine is for electricity generation. Electricity can be generated and stored in a battery or similar objects, for further usage. But other than the power generation, this turbine can be used for number of different purposes. It can be coupled with some mechanical assemblies for its automated drives. One of such application is, when the farmers have to dry their grains in minimum

Figure 4: The Testing Set-up of the Turbine

available area they can couple this turbine with a stirrer via geared assembly. This ensures drying of maximum grains even in minimum available area. This turbine was also used in the Robot for the driving purpose where the turbine was connected to the wheel by bevel gears for the driving of the robot (Figure 3). With the rotation of the turbine, it would give the robot its motion

6. Result and Discussion

The test rig was manufactured using the scaled down model of the turbine, and the wind effect was given with the Quadcopter, being fixed vertically. Use of the quadcopter was decided on the requirement of distributed wind amongst required area, and also high wind velocity was needed. The quadcoptor could satisfy all these needs. Hence it was decided to be used as the wind source. The testing set up is shown in the Figure 4. The scaling down of the design was required because it was hard to produce wind at desired speed in vast area, also, changes required would be very expensive in case of full scale model. The data acquired in the test rig is given in the table

As it can be seen in the observation table, the rotational velocity of the turbine increases exponentially in the first few steps. But It is stabilized after 50 mph. According to a paper published in Journal of Current Science, the average wind velocity in a city of India is 25-35 mph[6]. Whereas the peak velocity may go as high as 200 mph. As it can be seen in the table, the turbine works efficiently in the range of 30-100 mph which covers most of the span of wind speeds in the cities. Also it can be seen in the table that the turbine almost stalls at stormy speed of 250 mph. This is because the force acting on the front side and on the back side of the turbine almost equates at such a large speed, and results in stalling of the turbine. This property is also desired as it prevents the burning and over rotation of the generator.

Table 1: Rotational Velocity of the Turbine With Respect To Wind Velocity

Sr. No.	*Wind Velocity* (mph)	*Turbine RPM* (Rotaions per Minute)
1	10	18
2	20	91
3	30	145
4	40	204
5	50	245
6	70	249
7	100	251
8	150	219
9	200	157
10	250	09

7. Conclusion

This new type of the wind turbine is best suitable for the conditions where the wind flowing conditions are really not up to the limits of requirements of the present designs of the wind turbine. Also the design, being vertical in nature, is independent of the direction of the wind. Its rotational velocity is considerable even under very low wind conditions and it tends to stabilize under increasing wind conditions, which essentially avoids it getting damaged under stormy conditions

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Author Profile

Ashay Aswale received the B.Tech. degree in Mechanical Engineering from College of Engineering, Pune, in 2017. He was an active member of the Robotics Team of his college. He got into the field of designing various wind turbines in 2015. He used these several designs for the robot to be used in the robotics competition Robocon-2016. His team secured second position with the help of the deigns provided by him. His team also won the competition in the year 2017.